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METHOD FOR JOINING SILICONE GEL AND SUBSTRATE
[SHIRIKOON GERU TO SHIJITAI TONO SETSUGO HOHO]

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Specification

1. Title of the Invention

Method for Joining Silicone Gel and Substrate

2. Claims

1) A joining method for a silicone gel and a substrate, characterized in that a silicone primer is applied to the surface of a substrate, said silicone primer being capable of forming a chemical bond with a silicone gel to be joined to the substrate, and a silicone gel in an uncured state is brought into contact with the surface of the resulting substrate and is then heated in order to cure the silicone gel while the silicone primer thus applied to the substrate surface is reacted with the silicone gel in order to join the silicone gel to the substrate.

2) A joining method for a silicone gel and a substrate, characterized in that a silicone primer is applied to the surface of a substrate, said silicone primer being capable of forming a chemical bond with a silicone gel to be joined to the substrate, then an addition reaction type silicone adhesive agent that is capable of the silicone gel is applied to the substrate surface, and a silicone gel in an uncured state is brought into contact with the surface of the resulting substrate and is then heated in order to cure the silicone gel while the silicone primer thus applied to the substrate surface and/or the

adhesive agent are reacted with the silicone gel in order to join the silicone gel to the substrate.

3) A joining method for a silicone gel and a substrate, characterized in that a silicone primer is applied to the surface of a substrate, said silicone primer being capable of forming a chemical bond with a silicone gel to be joined to the substrate, then a silicone adhesive agent is applied to the substrate surface, said silicone adhesive agent being a mixture of diorganopolysiloxane and organohydrogen polysiloxane and having a molar ratio of the vinyl group of the diorganopolysiloxane to the hydrogen atom in the Si-H bond of the organohydrogen polysiloxane that provides a hydrogen excess state, and a silicone gel in an uncured state is brought into contact with the surface of the resulting substrate and is then heated in order to cure the silicone gel while the silicone primer thus applied to the substrate surface and/or the adhesive agent are reacted with the silicone gel in order to join the silicone gel

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to the substrate.

4) A joining method for a filler-containing silicone gel and a substrate, characterized in that a silicone primer and an optional silicone adhesive agent are applied to the surface of a substrate, said silicone primer being capable of forming a

chemical bond with a silicone gel to be joined to the substrate, a silicone gel in an uncured state containing no filler is applied to the substrate surface, a silicone gel in an uncured state containing a filler is then brought into contact with the surface of the resulting substrate and is then heated in order to cure the silicone gel while the silicone primer thus applied to the substrate surface and/or the adhesive agent are reacted with the silicone gel in order to join the silicone gel to the substrate.

3. Detailed Description of the Invention

Field of the Invention

The present invention relates to a joining method for a silicone gel and a substrate and, more specifically, the present invention relates to a joining method for a silicone gel and a substrate wherein the silicone gel and the substrate are firmly adhered to each other.

Technical Background of the Invention

A joint article that can be obtained by joining a silicone gel and a substrate, such as a mounting washer, has excellent performance as a shock absorber or a vibration isolator, and examples of expected application fields of the joint article include various rotating machines, precision devices, such as OA equipment, sporting goods, such as shoes, and special packaging materials.

A joint article obtained by joining a silicone gel and a substrate has been conventionally produced, for example, by curing and molding a silicone gel into a predetermined shape, and adhering the resulting molded article to a substrate by using an adhesive agent.

However, since silicone gels have high releasability, even in the case of using a silicone adhesive agent for adhering a silicone gel to a substrate, it is still difficult for the silicone gel to be firmly jointed to the substrate, thereby entailing a problem that the silicone gel is easily separated from the substrate.

Further, in order to improve the adhesion between the silicone gel and substrate, it is possible that a pre-treatment, such as sand blasting, is conducted on both the silicone gel that has been cured and molded into a predetermined shape and the surface of the substrate for adhesion before they are jointed together by using an adhesive agent. However, this method requires a complicated pre-treatment and further entails several problems, such as a large variation in the adhesion force.

Particularly in the case where the hardness of the silicone gel to be adhered to the substrate is high or in the case where a filler is incorporated into the silicone gel, it has been difficult for the silicone gel to be firmly jointed to the

substrate. For example, when a silicone gel having a penetration value of not more than 50 is intended to be jointed to a substrate, not only is the adhesion to the substrate decreased but also the compatibility with the substrate surface is insufficient, resulting in air bubbles being easily included during the joining process. Further, the silicone gel is too hard to be deformed and therefore stress concentration occurs as a result of uneven compression. Hence, it has been difficult for the silicone gel to be firmly jointed to the substrate. When a filler-containing silicone gel having a penetration value of not more than 200, such as a hollow balloon, is intended to be jointed to a substrate, the adhesion area of the silicone gel is decreased as a result of the addition of the filler and, further, the adhesion force between the silicone gel and the substrate is decreased due to the electrical repulsion (van der Waals force) between the filler and the substrate. Hence, it has been difficult for the silicone gel to be firmly jointed to the substrate.

Object of the Invention

The present invention is completed in view of the prior art as mentioned above and the object of the present invention is to provide a joining method for a silicone gel and a substrate wherein the silicone gel and the substrate are firmly jointed together.

Summary of the Invention

A first aspect of the present invention is a joining method for a silicone gel and a substrate, characterized in that a silicone primer is applied to the surface of a substrate, said silicone primer being capable of forming a chemical bond with a silicone gel to be joined to the substrate, and a silicone gel in an uncured state is brought into contact with the surface of the resulting substrate and is then heated in order to cure the silicone gel while

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the silicone primer thus applied to the substrate surface is reacted with the silicone gel in order to join the silicone gel to the substrate.

A second aspect of the present invention is a joining method for a silicone gel and a substrate, characterized in that a silicone primer is applied to the surface of a substrate, said silicone primer being capable of forming a chemical bond with a silicone gel to be joined to the substrate, then an addition reaction type silicone adhesive agent that is capable of the silicone gel is applied to the substrate surface, and a silicone gel in an uncured state is brought into contact with the surface of the resulting substrate and is then heated in order to cure the silicone gel while the silicone primer thus applied to the

substrate surface and/or the adhesive agent are reacted with the silicone gel in order to join the silicone gel to the substrate.

A third aspect of the present invention is a joining method for a silicone gel and a substrate, characterized in that a silicone primer is applied to the surface of a substrate, said silicone primer being capable of forming a chemical bond with a silicone gel to be joined to the substrate, then a silicone adhesive agent is applied to the substrate surface, said silicone adhesive agent being a mixture of diorganopolysiloxane and organohydrogen polysiloxane and having a molar ratio of the vinyl group of the diorganopolysiloxane to the hydrogen atom in the Si-H bond of the organohydrogen polysiloxane that provides a hydrogen excess state, and a silicone gel in an uncured state is brought into contact with the surface of the resulting substrate and is then heated in order to cure the silicone gel while the silicone primer thus applied to the substrate surface and/or the adhesive agent are reacted with the silicone gel in order to join the silicone gel to the substrate.

A fourth aspect of the present invention is a joining method for a filler-containing silicone gel and a substrate, characterized in that a silicone primer and an optional silicone adhesive agent are applied to the surface of a substrate, said silicone primer being capable of forming a chemical bond with a silicone gel to be joined to the substrate, a silicone gel in an

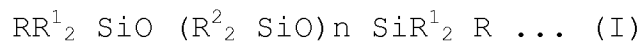
uncured state containing no filler is applied to the substrate surface, a silicone gel in an uncured state containing a filler is then brought into contact with the surface of the resulting substrate and is then heated in order to cure the silicone gel while the silicone primer thus applied to the substrate surface and/or the adhesive agent are reacted with the silicone gel in order to join the silicone gel to the substrate.

Detailed Description of the Invention

The inventive joining method for a silicone gel and a substrate is described in greater detail below.

In the present invention, where a silicone gel is jointed to a substrate, examples of the substrate include metallic substrates, synthetic resin substrates and ceramic substrates without restriction, and the shape of the substrate is also not particularly restricted.

An example of the silicone gel is a gel having a diorganopolysiloxane unit. In particular, the following gel can be preferably used as the silicone gel in the present invention: specifically, the preferred gel is an addition reaction type silicone copolymer consisting of a mixture of: diorganopolysiloxane (component A) that is denoted by the following formula (I):



[Wherein R denotes an alkenyl group; R^1 denotes a monovalent hydrocarbon group having no aliphatic unsaturated bond; R^2 denotes a monovalent aliphatic hydrocarbon group (in R^2 , at least 50 mol% is a methyl group. In the case where an alkenyl group is included, the content of the alkenyl group is not more than 10 mol%); and n denotes a number where the viscosity of the component at a temperature of 25 degrees Celsius is in a range of from 100 cSt to 100,000 cSt]; and organohydrogen polysiloxane (component B) in which the viscosity at a temperature of 25 degrees Celsius is not more than 5000 cSt and has hydrogen atoms which are directly coupled with at least 3 Si atoms in the molecule.

Further, the ratio (molar ratio) of the total amount of the alkenyl group in the diorganopolysiloxane (component A) to the total amount of the hydrogen atoms which are directly coupled with the Si atoms in the organohydrogen polysiloxane (component B) is in a range of from 0.1 to 2.0.

This silicone gel is described in greater detail in the following. Component A, which is diorganopolysiloxane,

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is a compound having a linear molecular structure, with the alkenyl groups R on both terminals of the molecule forming a crosslinked structure with hydrogen atoms which are directly coupled with the Si atoms in component B. The alkenyl groups on

the terminals of the molecule are preferably lower alkenyl groups and more preferably vinyl groups from the perspective of reactivity.

Further, R^1 which is present on the terminal of the molecule denotes a monovalent hydrocarbon group having no aliphatic unsaturated bond. Specific examples of such a monovalent hydrocarbon group include an alkyl group, such as a methyl group, a propyl group and a hexyl group, a phenyl group and a fluoroalkyl group.

In the above formula (I), R^2 denotes a monovalent hydrocarbon group. Specific examples of such a monovalent hydrocarbon group include an alkyl group, such as a methyl group, a propyl group and a hexyl group, and a lower alkenyl group, such as a vinyl group. However, in R^2 , at least 50 mol% is a methyl group. In the case where R^2 denotes an alkenyl group, the alkenyl group is preferably used in an amount of not more than 10 mol%. If the amount of the alkenyl group exceeds 10 mol%, the crosslinking density may become excessive, resulting in the viscosity being increased. Further, n is adjusted such that the viscosity of component A at a temperature of 25 degrees Celsius is generally in a range of from 100 cSt to 100,000 cSt, preferably in a range of from 200 cSt to 20,000 cSt.

Component B, which is organohydrogen polysiloxane, is used as a crosslinking agent for component A and cures component A by

adding the hydrogen atoms which are directly coupled with Si atoms to the alkenyl groups in component A.

Component B is sufficient if it has the above-described effect. The molecular structure of component B may have various structures, such as a linear structure, a branched structure, a chain structure, a cyclic structure and a network structure. Further, in addition to hydrogen atoms, the Si atoms of component B are coupled with an organic group. Examples of such an organic group include a lower alkyl group, such as a methyl group. The viscosity of component B at a temperature of 25 degrees Celsius is generally not more than 5000 cSt, preferably not more than 500 cSt.

Examples of component B are as follows:

Organohydrogen polysiloxane in which both terminals of the molecule are blocked with triorganosiloxane groups;

Copolymer of diorganosiloxane and organohydrogen siloxane;

Tetraorganotetrahydrogen cyclotetrasiloxane;

Copolymer siloxane consisting of $\text{HR}^1_2 \text{SiO}_{1/2}$ unit and $\text{SiO}_{4/2}$ unit; and

Copolymer siloxane consisting of $\text{HR}^1_2 \text{SiO}_{1/2}$ unit, $\text{R}^1_3 \text{SiO}_{1/2}$ unit and $\text{SiO}_{4/2}$ unit. In the above formulas, R^1 is the same as above.

The silicone gel used in the present invention can be produced by mixing component A and component B such that the

ratio of the total amount of the alkenyl group in component A to the total amount of the hydrogen atoms which are directly coupled with the Si atoms in component B is in a range of from 0.1 to 2.0, preferably in a range of from 0.1 to 1.0. The curing reaction of the silicone gel is usually conducted with a catalyst. Preferred examples of the catalyst that can be used in this reaction include platinum type catalysts include micropulverized platinum, platonic chloride, platinum oxide, a complex salt of platinum and olefin, platinum alcoholate and a complex salt of platonic chloride and vinyl siloxane. The amount of the catalyst used is generally not less than 0.1 ppm (on a platinum basis; the same applies below), preferably not less than 0.5 ppm, as against the total amount of component A and component B. The upper limit of the amount of the catalyst is not particularly restricted. For example, in the case where the catalyst used is in the form of a liquid or can be used as a solution, the use of the catalyst in an amount of not more than 200 ppm is sufficient.

The cure silicone gel thus obtained has a penetration value determined in accordance with JIS K 2207-1980 with 50 g load that is generally in a range of from 5 to 250, preferably in a range of from 10 to 70.

The hardness of the silicone gel can be adjusted by modifying the amount of component A to be higher than the amount

in which a crosslinked structure can be formed with hydrogen atoms which are directly coupled with Si atoms in component B.

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The hardness of the silicone gel can also be adjusted by adding a silicone oil in which both terminals have methyl groups in advance in an amount of from 5 wt% to 75 wt% as against the amount of the resulting silicone gel.

The above-described silicone gel may contain a filler (filling agent). Examples of such a filler include organic balloons, inorganic balloons, talc, mica, load powder, metal fibers, inorganic fibers, organic fibers, whiskers, conductive fillers and piezoelectric fillers.

Further, in addition to a filler, the silicone gel may contain various additive agents, such as pigments, curing accelerators and fire retardants, within a range where the characteristics of the resulting silicone gel are not impaired.

In the present invention, when the above-described substrate and silicone gel are jointed together, first, a silicone primer which is capable of forming a chemical bond with the silicone gel is applied to the substrate surface to be jointed. Subsequently, a silicone gel in an uncured state is brought into contact with the substrate surface to which a silicone adhesive agent has been optionally applied, and the resulting substrate is heated in order to cure the silicone gel

while the silicone primer thus applied to the substrate surface and/or the adhesive agent are reacted with the silicone gel, thereby joining the silicone gel to the substrate.

An example of the silicone primer which is capable of forming a chemical bond with the silicone gel is a primer which is capable of being jointed to the substrate and being reacted with the silicone gel.

Specific examples of such a silicone primer include Primer A (manufactured by Toray Silicone) and Primer Z-3042 (manufactured by Bayer Silicone composition).

Further, the silicone primer may contain a coupling agent, such as triethoxysilane.

In the present invention, it is preferred that an addition reaction type silicone adhesive agent should be further applied to the substrate surface to be jointed once the silicone primer has been applied.

Examples of such an addition reaction type silicone adhesive agent include a silicone adhesive agent which causes an addition reaction with a silicone gel by the application of heat and is capable of curing the silicone gel. Specific examples include KE-1800T (manufactured by Shin-Etsu Chemical Co., Ltd.) and SE-1700 (manufactured by Toray Silicone).

Examples of the addition reaction type silicone adhesive agent further include a composition which is a mixture of

diorganopolysiloxane and organohydrogen polysiloxane and has a molar ratio of the vinyl group of the diorganopolysiloxane to the hydrogen atom in the Si-H bond of the organohydrogen polysiloxane that provides a hydrogen excess state. For example, a composition in which the ratio of the vinyl group to the hydrogen atom in the Si-H bond is in a range of from 1 : 1.05 to 1 : 2.0 can be used.

The substrate surface to which the silicone primer and the optional silicone adhesive agent are applied is brought into contact with the silicone gel in an uncured state and is then heated. This heating process is preferably conducted with a mold. More specifically, the silicone gel in an uncured state is applied to the substrate surface which has been set in a mold and then the resulting substrate is heated in order to cure the silicone gel while the silicone primer thus applied to the substrate surface and/or the adhesive agent are reacted with the silicone gel in order to join the silicone gel to the substrate.

The application of heat is performed at a temperature of from 50 degree Celsius to 160 degrees Celsius, preferably from 70 degrees Celsius to 130 degrees Celsius. Further, the heating process can be conducted under a pressure of from 1.02 kg/cm² to 5.0 kg/cm².

Upon completion of the heating process, the resulting joint article comprising the silicone gel and the substrate is removed

from the mold and is then allowed to stand so as to be cooled, thereby obtaining a final product.

Further, in order to join a filler-containing silicone gel to a substrate according to the inventive method, a silicone primer and an optional silicone adhesive agent are first applied to the substrate surface to be jointed; a silicone gel containing no filler is then applied to the resulting substrate; subsequently, a filler-containing silicone gel is applied to the substrate

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in order to cure the filler-containing silicone gel, thereby joining the silicone gel to the substrate.

Effect of the Invention

A joint article comprising a silicone gel and a substrate that can be obtained in accordance with the inventive method has excellent adhesive force at the joined part and a small variation in the adhesive strength and therefore has excellent performance as a shock absorber or a vibration isolator. Specific examples of the application fields of the joint article include various rotating machines, precision devices, such as OA equipment, sporting goods, such as shoes, and special packaging materials.

Further, in the present invention, such a joint part comprising a silicone gel and a substrate can be produced by a simple method.

The present invention is described with reference to the following embodiments, but is not restricted thereto in any way.

Embodiment 1

A silicone primer (Primer A: manufactured by Toray Silicone) was applied to, and was dried on, the joining surface of two disk-shaped washers obtained from a zinc-plated carbon steel plate having a thickness of 3.2 mm. Thereafter, an addition reaction type silicone adhesive agent (KE 1800T; manufactured by Shin-Etsu Chemical Co., Ltd.) was applied to the resulting surface, and the resulting substrate was set on a base surface of the mold while the adhesive agent was in a wet state and had reactivity.

Next, both-terminal vinyl diorganopolysiloxane (component A) (X-32/902; manufactured by Shin-Etsu Chemical Co., Ltd.) and organohydrogen polysiloxane (component B) (CaT 1300; manufactured by Shin-Etsu Chemical Co., Ltd.) were mixed and stirred at a mixing ratio of 100 : 6 (weight ratio). This mixture contained a platinum catalyst at a content of 5 ppm on a platinum basis as against the total amount of the mixture. The resulting mixture was first defoamed and was then introduced into the mold.

The rest of the washer was set on the upper surface of the mold, and a suitable weight was mounted thereon. The resulting mold was left in an oven under a low pressure and was heated at a temperature of 120 degrees Celsius for 1 hour and at a temperature of 120 degrees Celsius for 2 hours without the mold. Once the silicone gel had been cured, the article was collected from the oven and was left at rest.

The resulting test piece was set in a tensile tester so as to be broken under tension at a rate of 500 mm/min.

The results are shown in Table 1.

Comparative Example 1

The same substrate as in Embodiment 1 was subjected to a primer treatment by the same procedures as in Embodiment 1. Meanwhile, starting materials for the production of the same silicone gel as in Embodiment 1 were mixed, were stirred, were defoamed and were then introduced into a mold so as to be cured. The joining surface of the resulting cylindrical silicone gel cured article was thoroughly roughened by using a #40 sand paper sheet, was washed with water, was dried, was degreased with acetone and was then subjected to a primer coating treatment. A silicone adhesive agent was applied to both the substrate and the silicone gel cured article, which were then set in a mold, were compressed under a small pressure, and were then heated in an oven at a temperature of 120 degrees Celsius for 3 hours so

as to be cured. The resulting test piece was subjected to the same tensile test as in Embodiment 1.

The results are shown in Table 1.

Table 1

Silicone gel shock absorber part: 45 ϕ × 25 h (mm)

	Embodiment 1	Comparative Example 1
Number of Samples (unit)	6	7
Average Breaking Force (kg.f)	94.7	42.1
Maximum Breaking Force (kg.f)	111.1	50.2
Minimum Breaking Force (kg.f)	83.7	28.6
Variation Factor (%)	9.5	17.5

Embodiment 2

In accordance with JIS K 6301, a silicone primer (Primer A) was applied to the joining surface of a resin test piece that had been cut into a specific size, was then dried and was set in a mold.

Subsequently, the same silicone gel starting materials used in Embodiment 1 were introduced into the mold and an upper mold was mounted thereon. In this case, in order to prevent the unnecessary part from being jointed, the part was masked by placing a Teflon sheet having a thickness of 100 μ m thereon.

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While a low pressure was applied to the upper mold, the mold was heated for curing in an oven at a temperature of 120 degrees Celsius for 3 hours. Once the mold had been removed from

the oven, the resulting article was separated from the mold and was left at rest at room temperature.

The results are shown in Table 2.

Embodiment 3

In Embodiment 2, a silicone adhesive agent (KB 1800T) was applied to the test piece that had been subjected to the primer treatment. The gel starting materials in an uncured state were introduced into the mold and were then cured.

The results are shown in Table 2.

Comparative Example 2

A silicone gel sheet that had been cured and molded into a predetermined thickness was first degreased with acetone, was subjected to a primer treatment, was dried, was coated with a silicone adhesive agent, was then jointed to the same test piece as in Embodiment 3 in an mold, and was heated and cured at a temperature of 120 degrees Celsius for 3 hours.

The results are shown in Table 2.

Table 2

	Embodiment 2				Embodiment 3			Comparative Example 2			
1. Resin Test Piece											
Material	6-Nylon	PC	ABS	PET	6-Nylon	ABS	PET	6-Nylon	PC	ABS	PET
(Manufacturer)	(EMS)	(Teijin)	(Ube)	(Toray)	(EMS)	(Ube)	(Toray)	(EMS)	(Teijin)	(Ube)	(Toray)
Shape	Thin Plate	Thin Plate	Thin Plate	Film	Thin Plate	Thin Plate	Film	Thin Plate	Thin Plate	Thin Plate	Film
Thickness (mm)	2.5	1.1	1.55	0.025	2.5	1.55	0.025	2.5	1.1	1.55	0.025
2. Joining Surface Treatment											
Primer A	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
KE-1800T Coating	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
3. Breaking Strength											
Average Breaking Load (kgf)	1.05	1.01	0.63	1.14	1.63	1.79	1.19	0.15	0.05	0.20	0.23
Maximum Breaking Load (kgf)	1.12	1.10	0.70	1.19	1.70	2.09	1.30	0.20	0.05	0.28	0.28
Minimum Breaking Load (kgf)	0.98	0.91	0.55	1.08	1.56	1.55	1.00	0.11	0.05	0.13	0.17
Breaking Point	Gel	Gel	Interface	Gel	Gel	Gel	Gel	Interface	Interface	Interface	Interface
Other				T-Shape Peeling Test			T-Shape Peeling Test				T-Shape Peeling Test

Embodiment 4

In Embodiment 3, a silicone gel starting material that had been prepared such that the ratio (weight ratio) of the vinyl group to the hydrogen atom in the Si-H bond was 1 : 1.05 was used instead of the silicone adhesive agent. The material was introduced into the mold and a predetermined mixture silicone gel starting material was cured.

The results are shown in Table 3.

Comparative Example 3

A silicone gel was jointed to a substrate by the same method as in Embodiment 4, except that a silicone gel that had been cured in advance was used.

The results are shown in Table 3.

Table 3

	Embodiment 4		Comparative Example 3	
1. Resin test piece				
Material	6-nylon	PET	6-nylon	PET
(Manufacturer)	(EMS)	(Toray)	(EMS)	(Toray)
Shape	Thin plate	Film	Thin film	Film
Thickness (mm)	2.5	0.025	2.5	0.025
2. Breaking Strength				
Average Breaking Load (kgf)	0.82	1.48	0.15	0.23
Maximum Breaking Load (kgf)	0.84	1.84	0.20	0.28
Minimum Breaking Load (kgf)	0.80	1.28	0.11	0.17
Breaking Point	Gel	Gel	Interface	Interface
Other		T-Shape Peeling Test		T-Shape Peeling Test

Embodiment 5

In Embodiment 3, once the silicone adhesive agent had been applied, a silicone gel starting material containing no filler was applied at a thickness of 0.5 mm and then a silicone gel starting material containing 3 wt% of a hollow filler (Expancel DE; manufactured by Expancel (Sweden)) was introduced and cured.

The results are shown in Table 4.

Comparative Example 4

A silicone gel was jointed to a substrate by the same method as in Embodiment 5, except that a silicone gel sheet constituted of a hollow filler-containing silicone gel that had been cured in advance was used.

The results are shown in Table 4.

Table 4

	Embodiment 5			Comparative Example 4		
1. Resin Test Piece						
Material	Carbon Steel	6-Nylon	PET	Carbon Steel	6-Nylon	PET
Shape	Thin Plate	Film	Film	Thin Film	Thin Plate	Film
Thickness (mm)	1.6	2.5	0.025	1.6	2.5	0.025
2. Breaking Strength						
Average Breaking Load (kgf)	2.11	2.12	1.52	1.01	0.21	0.88
Maximum Breaking Load (kgf)	2.40	2.30	1.58	1.21	0.28	1.22
Minimum Breaking Load (kgf)	1.90	1.76	1.50	0.78	0.15	0.78
Breaking Point	Gel	Gel	Gel	Gel	Interface	Gel
Other			T-Shape Peeling Test			T-Shape Peeling Test